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Original Article

# DEVELOPMENT OF TECHNOLOGY FOR APPLYING SLUDGE FROM THERMAL POWER PLANTS IN THE PRODUCTION OF DRY PLASTER MIXTURES

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***ABSTRACT***

***The article presents the results of experimental studies of authors on the development of compositions and technology for the production of dry plaster mixtures on the basis of fly ash of thermal power plants. This technology includes the production of slag binder by mechanochemical activation of blast-furnace granular slag with hardening activators and preparation of dry mixtures with the introduction of mineral, polymeric, reinforcing and air-entraining additives into their composition. The problem of accumulation in Kazakhstan of a significant amount of ash-and-slag waste from thermal power plants and their negative impact on all natural environments is highlighted. The grain composition of TPP wastes is briefly described, as well as the process of their formation. The results of studies on the effect of the addition of mechanically activated ash on the properties of plaster solutions are presented. Standard methods of research were used in the work, including technological methods, X-ray diffraction and chemical analysis of substances. For particle size distribution, the laser granulometry method was used. The test was carried out on the device "Microsizer 201A". Described are the compositions of dry plaster mixtures of M35 and M50 grades developed by the authors, the mineral part of which consists entirely of production waste and local raw components. The economic efficiency of the developed compositions of dry plaster mixtures, which is caused by the replacement of Portland cement with cheaper slag binder, is revealed. As a base of comparison, mixtures were chosen for Portland cement, used in plants of dry construction mixtures. Also, the environmental benefits of using the proposed method for processing ash and slag wastes, which consist in a significant improvement of the environmental situation in and around the TPP.***

***KEYWORDS:** Cogeneration Station, Ash-Slag Waste, Ash-Slag Dumps, Cellular Concrete, Dry Plaster Mixtures, Resources Economy & Green Economy*

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## INTRODUCTION

Energy providers, in particular Thermal Power Plants (TPPs) constitute one of many environmental pressures related to the thermoelectric power industry. All TPPs in the world annually emit about 700 million tons of the different hazardous pollutants. Huge areas are occupied by ash dumps. In particular, Kazakhstan has accumulated 430 million tons of ash-and-slag waste (Sraubaev et al., 2014). In addition, the environmental consequences of

nuclear weapons testing at the Semipalatinsk test site and the emissions from industrial facilities cause irreparable environmental damage (Kakimovet al., 2016; Duyssembaev et al., 2014).

The accumulated ash-and-slag wastes exert substantial pressure on the environment and have geomorphological, hydrogeological, geochemical, geothermal, engineering-geological, mineralogical and geophysical consequences. So, adverse zones of ash dumps cause unfavorable ecological situations due to dust formation, as well as washing out of ash components (radionuclides and heavy metals), their entry into soil and groundwater, which in turn poses a danger to public health and a threat to flora and fauna of the surrounding areas. In addition, ash dumps result in alienation of large areas of land for the purpose of their construction to house ash-and-slag wastes that are practically irretrievably removed from their useful use, even after their reclamation, and their maintenance requires significant operating costs, which raises the cost of producing energy carriers (Alam et al., 2011). One of the problems of storage of ash and slag at the ash dump is their location near large cities, and often within the city. There is the problem of deformation of the surface and changes in the relief.

Ashes are technogenic mineral formations, and are generally described as products of pyrotechnic processes occurring in combustion chambers of thermal power plants. Depending on the type of solid fuel and the physicochemical processes occurring in these boilers, the formation of ash and slag occurs without melting, or with it, or complete melting of the initial components, accompanied by the evolution of gas and vapor substances, decarbonization, melting, crystallization and silicate formation of the original raw materials.

Ash and slag wastes according to their grain composition are divided into ash and slag. A conditional boundary between them can be taken as a fraction of 0.25 mm: smaller wastes are referred to as ash, larger ones to slag. When removing small and light fractions, which are carried away by flue gases from combustors and trapped by TPP filters, the ash of dry selection is concentrated in the ash collectors (Soloviyev and Pronin, 2011). It comes either directly to transport facilities, or to consumer stores. When cleaning the ash collectors with water, ash and slag in the form of pulp are removed into the dumps. The main mass of ash and slag is stored at these dumps, available at each TPP.

At the same time, ash and slag wastes in chemical and mineralogical composition are in many respects identical to natural mineral raw materials. Therefore, slag and ash have a good prospect for widespread use of them for the purpose of resource saving, that is, solving economic problems associated with preserving the natural resources of non-ferrous, rare metals and other materials.

The construction industry is the most promising consumer of ash and slag wastes. First of all, they are used as a partial or complete replacement of sand in the manufacture of heavy concrete. It is especially advantageous to introduce ash and slag mixture instead of fine-grained sand, which requires an increased consumption of cement. Concrete, in which the ash and slag mixture is combined with crushed stone, is not inferior in strength to concrete on high-quality aggregates (Umbetova, 2009).

Dry construction mixtures are designed for various types of work, but are mainly used in finishing work. The bulk of dry building mixtures are low-quality solutions used for the manufacture of plaster, masonry and glue mixtures. Astringent in these solutions is, as a rule, cement grade M400, which is irrational. Ash and slag mixture or slags, used in combination with conventional aggregates, improve the grain composition and workability of the concrete mixture while

saving expensive fillers. It is very important that in this case, it becomes possible to achieve up to 25% savings in cement (Malchiket al., 2016).

It should be noted that if in the CIS countries ash-and-slag is still referred to as waste, in Western countries they are officially called by-products of TPPs and are offered to potential consumers in the form of technologically advanced products that meet the requirements of regulatory documents in the field of construction. Due to this circumstance, in developed countries 70-95% of ash and slag are used from the volumes of their output, and in the Netherlands and Denmark - 100% (Shamshadet al., 2012). Ash dumps at TPPs have been virtually eliminated in Western Europe and Japan (Jamilet al., 2009).

Our country faces the ambitious task of transition from «brown economy» to «green economy», which was announced in the President's Address to the People of Kazakhstan in the«Kazakhstan-2050» Strategy. In more detail, the waste management system is considered in the normative document «Concept on the Transition of the Republic of Kazakhstan to Green Economy». In particular, to reduce the volume of industrial wastes, it is intended to define «options for processing / dumping hazardous and toxic wastes» (Concept, 2013).

The objectives of this paper are to study the physical and chemical properties of ash and slag wastes, to determine the possibility of using them as a source of secondary resources to reduce the anthropogenic load on the environment, to develop a technology for obtaining dry plaster mixtures with the addition of fly ash and slag generated at TPPs.

## MATERIALS AND RESEARCH METHODS

Standard research methods, including technological methods, the method of X-ray structural and chemical analysis of substances were mainly used in the present work. For particle size distribution, the laser granulometry method was used. The test was carried out on the Microsizer 201A device manufactured by the St. Petersburg Plant VA Instalte LLC. The device consists of an optical-analytical unit, a sample preparation unit and a computer. The optical analytical unit is equipped with a laser device for counting particles; the sample preparation unit is equipped with an ultrasonic disperser. The particles in the slurry are fed by a centrifugal pump with a stirrer; the rotor speed is 3,000 rpm. The combined action of the ultrasonic disperser and the centrifugal pump excludes the possibility of the particles sticking together as they are being measured. Surface tension of aqueous solutions of surface active agents, which were used in the work for air entrainment into the plaster mixture, was determined by the stalagmometric method using a glass capillary tube.

The viscosity of surfactant solutions was determined with the Ubbelohde capillary viscometer, which is a U-shaped tube with equal-sized small tanks (balls) of the same volume.

## RESULTS AND DISCUSSIONS

The composition of ash and slag material was determined by the quantitative ratio of the minerals included in it, which depend on the mineralogical composition of the initial part fuel. Knowledge of the chemical composition of ash and slag wastes is a prerequisite for judging its properties and solving the problem of their possible using in the production of dry construction mixtures.

Selected samples of ash were examined for chemical composition. The chemical composition of ashes form the Almaty TPP is given in table 1.

**Table 1: The Chemical Composition of Ashes form the Almaty TPP**

| Element | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | FeO | $TiO_2$ | CaO | MgO | $SO_3$ | $K_2O$ | $Na_2O$ | $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Q-ty, % | 58,45 | 26,86 | 1,56 | 1,33 | 0,86 | 2,15 | 0,35 | 0,57 | 0,21 | 0,04 | 3,45 |

Table shows that ash from the Almaty TPP belongs to the super-acid substances, since the ratio of the sum of CaO and MgO to the sum of $SiO_2$ and $AlO_3$ is 0.03, i.e. is two orders of magnitude less than unity. In this case, since the ash is mainly represented by a glass phase, its high chemical activity is obvious when incorporated into a cement or slag binder. The specific ash surface determined on the PXX-2 device was 3100 $cm^2$ / g.

Ash according to its chemical composition satisfy the requirements for ash filler used in the manufacture of unreinforced concrete structures, which include plaster solutions (Pshenichny, 2009; Safiuddin et al., 2010). Scientific research of recent years shows the high efficiency of mechanical activation in the preparation of cement and gypsum binders (Kuzmina, 2007; Shannon et al., 2009). Therefore, of considerable interest is mechanical activation of ash and its introduction as an active component of a binder in the composition of the plaster mixture together with portland cement.

For the purpose of mechanical activation, the ash was pre-dried at 105 °C until the material reached a constant mass and, after cooling, was milled for various times (0.5, 1.5 and 3 hours) in a two-chamber laboratory ball mill with a diameter of 50 cm and a working volume of material of 50 kg. The tests were carried out both without adding of additives, and with adding a super plasticizer C-3 and additive X.

The results of the solution samples testing are shown in table 2.

**Table 2: The Effect of the Addition of Ash on the Density and Strength of the Solution**

| Mixture Composition, kg | Based on the Ash Crushed During, h | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | - | | | 0,5 | | | 1,5 | | | 3 | | |
| Cement | 350 | 300 | 200 | 350 | 300 | 200 | 350 | 300 | 200 | 350 | 300 | 200 |
| Ash | 50 | 100 | 200 | 50 | 100 | 200 | 50 | 100 | 200 | 50 | 100 | 200 |
| Sand | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| Water | 320 | 320 | 340 | 320 | 320 | 340 | 320 | 320 | 340 | 320 | 320 | 340 |
| **Solution Properties** | | | | | | | | | | | | |
| $\rho$ after steaming, kg / $m^3$ | 2000 | 2025 | 1955 | 2010 | 2055 | 2010 | 2100 | 2025 | 1985 | 2040 | 2000 | 1970 |
| $\rho$ in dry basis, kg / $m^3$ | 1730 | 1785 | 1715 | 1760 | 1760 | 1715 | 1830 | 1760 | 1685 | 1785 | 1730 | 1715 |
| $R_{сж}$after steaming, MPa | 3,5 | 4,7 | 4,0 | 4,9 | 5,7 | 4,4 | 5,4 | 6,1 | 5,2 | 5,0 | 6,4 | 6,4 |
| $R_{сж}$after hardening for 28 days, MPa | 8,2 | 9,0 | 6,8 | 9,5 | 10,4 | 7,2 | 11,2 | 11,7 | 7,3 | 9,3 | 11,6 | 8,2 |

Characteristics of the control composition made at a cement consumption of 400 kg, sand - 1000 kg and water - 300 l: average density after steaming and in a dry state, respectively, 2080 and 1830 kg / $m^3$, compressive strength, respectively, 4.7 and 12.1 MPa.

Analysis of the experimental data obtained shows that by introducing mechano activated ash, it is possible to reduce cement consumption by 50%, i.e. from 400 to 200 kg and thus the grade of a solution does not decrease - remains at level M100, as well as a control structure. With the introduction of unmilled ash in an amount of 25 and 50%, the strength of the samples decreases from 12.1 to 8.2 and 6.8 MPa, respectively (Aleksandrova and Klyagin, 2014).

It is interesting to note the following fact: in all cases, the strength of samples with the addition of ash in an amount of 100 kg (cement-ash ratio is 3: 1) is higher than that of samples with less ash additions, i.e. samples with an ash

additive of 50 kg (cement-ash ratio is 7: 1). Since the density of samples is approximately equal, it can be concluded that in this case the chemical processes associated with the hydration of clinker minerals of cement and active components of ash begin to play a dominant role (Krikunovaet al., 2009; Guet al., 2018).

During the research, the raw materials used were:

- Blast-furnace granulated slag from the Arcelor Mittal Combine;
- Quartz-feldspar sand fromthe Kapchagai deposit in Almaty region, the sand size modulus is 1.48, the silica content is 37%, the feldspars - 60.1%, the mica - 1%, the pulverized and clay particles - 1.9%;
- Flue ash from the Almaty TPP, SiO2 content - 88%;
- Chemical additives: foaming agent - sulfonate, sodium sulfate, potassium sulfate, cellulose ethers, redispersion powders, MB and Relamix plasticizers, Melfluxhyperplasticizer. All additives meet the requirements of the relevant standards.

Below are the results of experimental studies on the development of compositions and technology of slag binder. In accordance with the working hypothesis, local materials, in particular quicklime and hydrated lime, as well as gypsum, were tested as hardening activators. As the controlled parameters, the compressive strength and bending strength and the setting time of the slag binder were chosen. Grinding of the original components was carried out to the requirements of the standard, i.e. before reaching slag, lime and gypsum the specific surface area is about 3000 $cm^2$ / g.

According to the research findings (Table 3), the introduction of a complex additive in an amount of 15% is optimal, at which the setting of the slag binding agent is sharply accelerated, and the effect of synergism is clearly visible in the action of the additives. Calculations show that the 15% complex additive contains 2.45% of gypsum, 0.25% of sodium or potassium sulfate and 12.3% of ash.

**Table 3: The Effect of a Complex Additive on the Timing of Setting The Slag Binder with the Addition of 10% Slaked Lime**

| Name of Salt in the Composition of the Additive | Setting Time, hour-min | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Initial Setting with the Content of the Complex Additive,% | | | | Initial Setting with the CONTENT of the Complex Additive,% | | | |
| | 0 | 10 | 15 | 20 | 0 | 10 | 15 | 20 |
| sodium sulfate | 12-00 | 3-20 | 1-35 | 0-40 | 21-00 | 6-30 | 4-45 | 3-30 |
| potassium sulphate | 12-00 | 2-30 | 1-25 | 0-20 | 21-00 | 5-50 | 4-50 | 3-15 |

The test results showed the possibility of obtaining a binder with a compressive strength of 8-9 MPa, for bending – 2, 5-3 MPa. To regulate the setting time and as an additional sulfate hardening activator, crushed gypsum and also sodium and potassium sulfate were added to the binder composition. Since the introduction of individual additives did not allow us to obtain satisfactory results on the setting time, studies were carried out to obtain a complex hardening accelerator using a tribrach and additional grinding of the components. As a tribrach, flue ash from the TTP was used. The optimum ratio of the composition of the complex additive is taken as follows: gypsum: salt: tribrach - 2: 0, 2: 10.

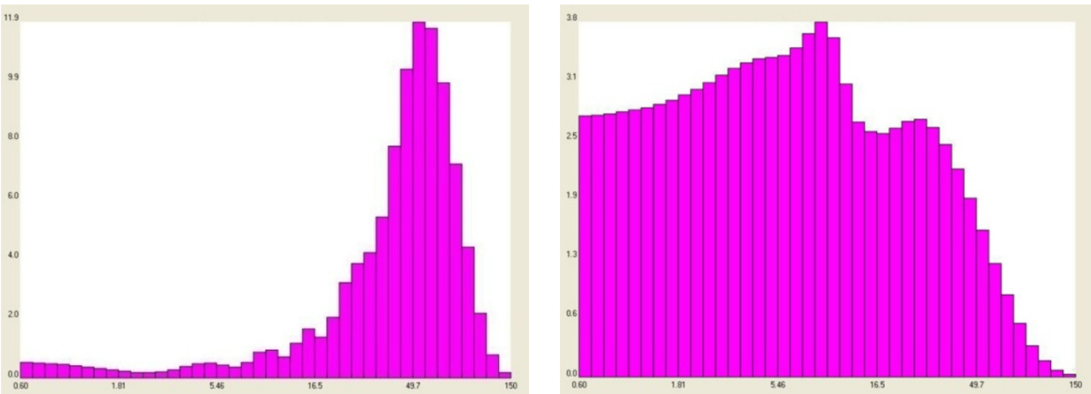
Taking into account the insufficient strength of the slag binder using standard methods of its activation, appropriate studies were conducted to improve the brand strength of the material. As a basis, a mechanichemical activation method was used in combination with an increase in the fineness of grinding of the binder and the use of plasticizers of the last generation, in particular polycarboxylatehyper plasticizers.

In preparing the slag binder to increase the homogeneity of the mixture and maximize the activation of components, the initial materials were first mixed and then grinding was carried out in a ball mill in a dry environment.

The research established that by adding the surfactant to the mixture, the process of dispersing the binder is accelerated rather sharply. Moreover, the addition of the Melfluxhyperplasticizer provides a significantly greater effect compared to the addition of the MB superplasticizer on the naphthalene formaldehyde basis. So, with the same amount of additive equal to 0, 7%, the fineness of grinding after 6 hours is 4 150 and 4 850 $cm^2$ / g for MB and Melflux respectively.

One of the main indicators of raw materials is their granulometric composition. The higher the micro dispersion content of particles, the higher the plasticity of the material (Timakov, 2008; Oliveira et al., 2013). Consequently, the raw material will have a high degree of cohesion, which will positively affect the strength characteristics of the finished products, as well as the granulometric composition is important for determining the adsorption capacities of the material.

For compounds of slag binder intended for use in the preparation of low-quality plaster mixtures, it is important to have more fine particles (Ribeiro et al., 2013). The data obtained on the laser device showed that when the slag is mechanically activated in the presence of the Melfluxhyperplasticizer, the proportion of reactive fines increases sharply: grains smaller than 6 μm exceed 50%, and less than 30 μm 80% (Figure 1, Table 4).



(a) (b)

**Figure 1: The Histograms of the Distribution of Slag Particles Crushed without Additive (a), and Mechano Activated with the Addition of Melflux (b)**

**Table 4: The Distribution of Particles in terms of the Size of Mineral Components of the dry Plaster Mixture on the Slag Binder**

| Component | Grains Fraction of Dry Mix Components (%) at a Size (μm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 | 60 | 80 | 100 | 120 | 150 |
| Granulated slag, crushed without additives | 9,0 | 15,3 | 25,1 | 36,4 | 52,0 | 67,9 | 88,7 | 97,0 | 99,4 | 100 |
| Granulated slag, crushed for 20 minutes. with GP | 64,4 | 78.8 | 86,7 | 91,9 | 95,2 | 97,1 | 99,1 | 99,7 | 100 | 100 |

All additives of plasticizers, both the third (MB, Relaxix) and the fourth (Melflux) generations, reduce the water demand of the slag binder (Martinello et al., 2014; Oliveiraet al., 2014). By the efficacy, the hyperplasticizer on the polycarboxylate base significantly exceeds the additives of the "polyplast" series, which is based on the naphthalene formaldehyde superplasticizer C-3, at dosages much lower than when adding MB and Relamix. Thus, with the addition of Melflux in an amount of 0.5%, the normal density of the slag binder is reduced from 30% to 20%, while with the addition

of the same amount of MB, the water demand for the test material decreases to only 26%. To reduce the normal density of the slag binder to 22-23%, the dosage of MB and Relamix additives reaches 3%.

The results of tests to determine the strength of the slag binder, prepared by mechanochemical activation, showed that the introduction of plasticizing additives leads to an increase in the strength of the material while reducing its water demand.

The strength of the slag binder with increasing dispersion always increases and it acquires the greatest strength (30 MPa) at a specific surface of 5 000 $cm^2$ / g.

Optimum consumption of the Melfluxhyperplasticizer is 0.3-0.5% of the mass of the slag binder.

It should be noted that the Melflux additive has a very strong accelerating effect on the setting timing of the slag binder. But it should also be noted that the maximum effect is provided precisely with the fine grinding of the binder.

Experimental data showed that in all cases the addition of fillers in an amount of 20-30% leads to an increase in the strength of the solution. The greatest effect is achieved when using mechanochemically activated ash, the content of which can be brought up to 40% of the mass of the binder. In this case, the strength of samples is increased by 30-35% and to obtain a solution with the grade of strength M25-M50, it is sufficient to introduce a slag binder in an amount of 150-200 kg per 1 ton of the mixture.

Thus, the developed composition of M200 and M300slag binders, includes, %: fine-grained blast-furnace granulated slag - 83-95; lime - 7-9; gypsum - 3-5 and Melfluxhyperplasticizer - 0,25-0,3.

The choice of plaster mixture included the development of measures to reduce the density of the solution. Typically, the density of solutions is 1800-1900 kg / $m^3$, while solutions with a density of less than 1500 kg/$m^3$, that is, light, are effective (Makarchenko and Khlopitsky, 2013).

Traditionally, manufacturers of dry construction mixtures, including in Almaty, introduce a mixture of expanded perlite sand to reduce the density of solutions. The carried out technical and economic analysis showed its use inappropriate because of the high cost and significant water demand of the material.

A significant technical and economic effect is provided by applying the pore method to reduce the density of materials produced on the basis of mineral binders (Pei-wei et al., 2007; Pokale, 2012). Essentially, in this case, the role of porous filler is played by an airy pore, formed either by air entrainment or by gassing. The difference between air aggregate and solid porous aggregate is the lack of strength. At the same time, this factor is not always predetermining in all cases. In particular, both expanded vermiculite and expanded perlite are characterized by low structural strength and they are not able to create independently a skeleton of a material with a strength of 5 MPa or more, such as expanded clay (Vovk, 2009; Hossainet al., 2015). In addition, expanded perlite sand due to a highly developed surface requires the introduction of an increased amount of mixing water, which also leads to a reduction in the strength of the material (Ribeiroet al., 2010).

From the air-entraining admixtures, foaming agents are technologically acceptable, since it is not possible to increase the porosity of the plaster coating immediately after application to a wall or ceiling by gassing (Vovk, 2007; Andreeva, 2011).

Taking into account the cost of the additives, experimental studies were carried out using the hostapur OSB, ufapore CC 85 and sulfonate additives. All of them are white powder. The external difference between them is that the German and Finnish additives are more dispersed (average grain size is about 150-200 μm), while the sulfonate grains have a size of mostly 1-2 mm, i.e. an order of magnitude more.

The obtained data showed a high efficiency of the introduction of foaming surfactants in the compositions of dry plaster mixtures based on slag binders. Addition of surfactants in the amount of 0,2-0,4% ensure by foaming the reduction in the density of plaster solutions to 800-1400 kg/m$^3$. A greater effect is achieved with the use of the hostapur OSB additive and a smaller one - when using the sulfonate.

Thus, based on a comprehensive assessment of the three types of surfactants, the most appropriate is the use of a sulfonate. Despite the fact that with the introduction of sulfonate, the density of the solution is reduced to a lesser extent, but given its lower cost and technical characteristics, this additive provides a higher technical and economic effect.

The most important properties of mortar mixtures are their water-retaining ability and adhesion to different surfaces.

The adhesion of the plaster coatings to various substrates is an important characteristic that allows assessing the possibility of using the finishing material for the reliability of the adhesion of the plaster mixtures to the material of the finished surface, in particular concrete or brick (Cherencova and Olesik, 2013;Quispeet al., 2012).

Through studies of adhesion, the influence of the Winnapas RI 551 Z redispersive powder and MH 15002 P6 methyl hydroxyl ethyl cellulose was revealed. It was established that the use of methyl hydroxyl ethyl cellulose in the amount of only 0.05-0.1% of the weight of the dry mixture is sufficient for plaster solutions, at which the adhesion strength of 0,5-0,6 MPa is required, according to SNiP 3.04.01-87.

The technological and physical-mechanical properties of plaster solutions based on slag binders and ash filler were studied. The material at an average density of 1000-1200 kg / m$^3$ is characterized by compressive strength of 3,5-8,6 MPa, bending strength 1,4-3,5 MPa, and a frost resistance grade F35.

The proposed production of dry plaster mixtures on the basis of production waste includes the production of slag binder by mechanochemical activation of blast-furnace granular slag with curing activators and preparation of dry mixtures with the introduction of mineral, polymer, reinforcing and air-entraining additives into their composition, their packaging and shipment to the consumer.

The technology of dry plaster mixtures consists of the following operations:

- drying of blast-furnace granulated slag;
- drying of sand;
- grinding of blast-furnace granulated slag;
- supply of raw materials to the supply hopper;
- dosing of mineral raw materials and feeding them to a centrifugal mixer;

- dosing and supply of chemical additives to a centrifugal mixer;
- mixing of the mixture components;
- packing the mixture;
- warehousing of finished products.

Economic efficiency of the developed compositions of dry plaster mixtures is due to the replacement of portland cement with cheaper slag binding. As a base of comparison portland cement mixtures that used in plants of dry construction mixtures were chosen.

According to the results of experimental studies by the authors, the use of mechanically activated ash allows to reduce cement consumption by up to 50% in the dry mix composition. The economic effect from the introduction of research results averages 7,500 tenge per 1 ton of the mixture, and with the release of 100 thousand tons of the mixture per year it will be 750 million tenge. Taking into account that 430 million tons of ash-and-slag wastes have been accumulated in Kazakhstan, these developments are a definite contribution to the solution of the problem of ash and slag utilization at TPPs.

The testing of formulations and technology was carried out in production conditions at the POLIMIN KZ LLP. In the same place, a pilot batch of a dry plaster mix was produced, the approbation of which was successfully carried out during the decoration of the walls at the Central District Hospital in Yesik City. The mortar applied to the wall was treated in the same way as for the conventional cement mortar. The mass was technological during processing, and after solidification it had a uniform appearance without cracks and any visible defects. According to the conclusion of specialists, the composition of the dry plaster mixture meets the requirements of the standard and can be used for plastering the walls of residential and public buildings and structures.

## CONCLUSIONS

According to the studies conducted, the ash from the Almaty TPP is mainly represented by a glass phase, that is, its high chemical activity is obvious when it is introduced into the cement or slag binder. Thus, in terms of chemical composition, it meets the requirements for ash filler used in the manufacture of unreinforced concrete structures, to which plaster solutions can be referred. The mineral part of compositions of dry stucco mixes of grades M35 and M50, developed by the authors, consists entirely of production waste and local raw components. Compositions of dry plaster mixtures include finely ground granulated slag, hydrated lime, gypsum, flue ash from the TPP, sand, Melfluxhyperplasticizer, water-retaining additive, sulfonate and arbocel micro-reinforcing additive.

The developed one-stage process scheme for obtaining a dry plaster, providing for the preparation of a binder on one line and a mixture on its basis, is one of the mass-consuming ways of utilizing production wastes that effectively solve ecological and environmental issues, sustainable development of the region, and reduce the use of natural mineral resources. Research results can be used directly for introduction into production. Experimental and industrial testing of the technology confirmed the technical and economic efficiency of the use of granulated slag and flue ash from thermal power plants in the production of dry plaster mixtures.

Based on the foregoing, it can be concluded that the developed technology for obtaining dry plaster mixtures with the addition of flue ash and slag generated from TPPs can significantly reduce their negative impact on the environment and improve the economic performance of enterprises in the Republic of Kazakhstan.

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